Interactive Oracle Arguments in the QROM and Applications to Succinct Verification of Quantum Computation

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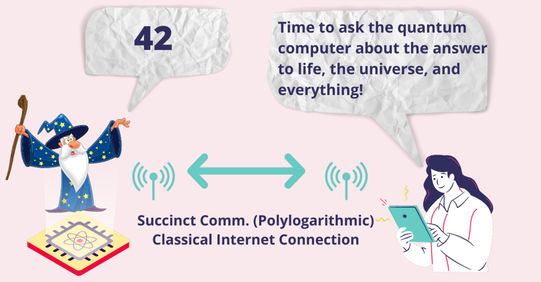
Motivating Question

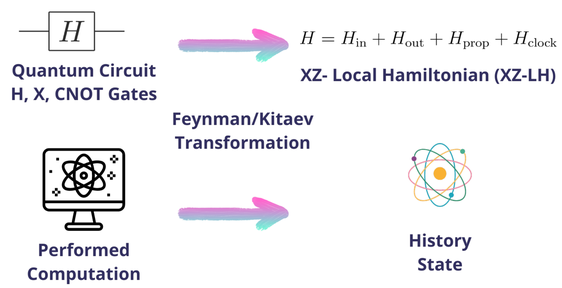


Can Merlin convince Alice of his answer?

Model and Assumptions

- The Quantum Random Oracle Model (QROM) [BODF+10, Zha18, DFMS21] with $\mathbf{RO} : \mathcal{X} \to \{0,1\}^\lambda$
- Non-succinct setup phase independent of the instance (task)
- Quantum Hardness of the Learning With Errors (LWE) problem
- XZ Quantum PCP Conjecture: XZ-LH problem is hard with $\tilde{O}(1)$ promise gap (Open Problem)

Step 1: Circuit-to-Hamiltonian



Step 2 [Mah18, ACGH20]: Convert the XZ-LH Proof System of [MNS16, MF16] into a Classical Argument

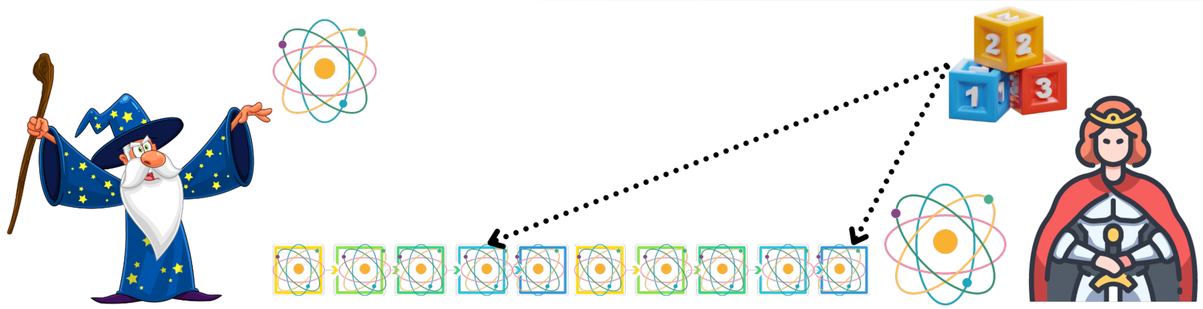
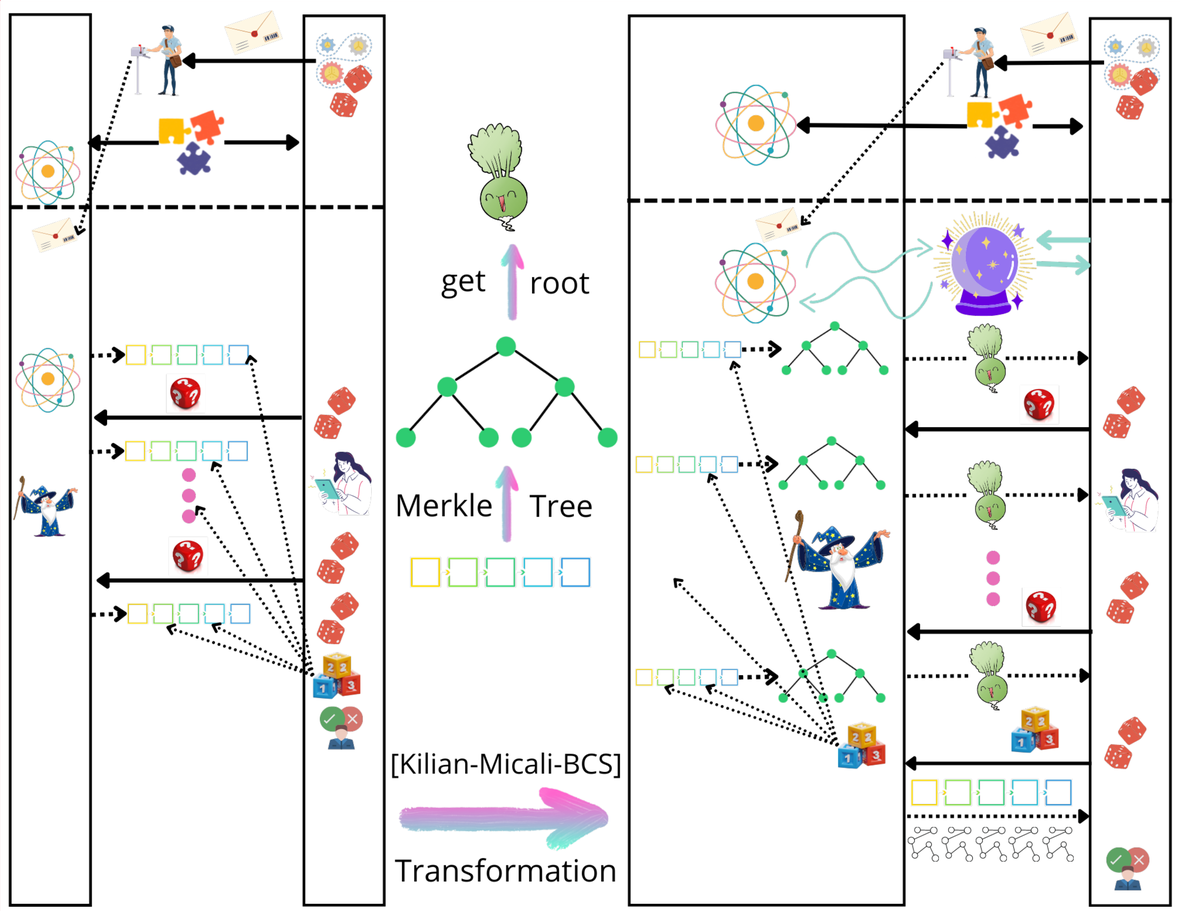


Illustration of the XZ-Quantum PCP Conjecture.
Step 2 when applied to XZ-LH proof system (a.k.a quantum PCP) with $\tilde{O}(1)$ query complexity yields an IOArg with succinct query complexity.

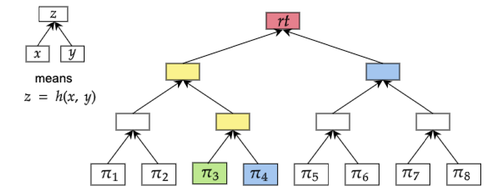
Step 3: Succinct Argument from Interactive Oracle Argument (IOArg)



Interactive Oracle Arguments (IOArgs) extend interactive oracle proofs (IOPs) [BSCS16].

Verifiable Measurement [Mah18]

Merkle Trees



A *Merkle tree* example of depth $d = 3$ to commit to $2^3 = 8$ *leaves* with the *root* rt.

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Preprint

`https://eprint.iacr.org/2023/421`

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